

MEASUREMENT OF INTENSITY OF TURBULENCE
IN DRAG REDUCING AND NON-DRAG REDUCING
ORGANIC SOLUTIONS

Research Grant
NGR 26-003-003
To University of Missouri at Rolla

First Semi-Annual Report

February 1 through August 1, 1965

FACILITY FORM 602	N 65 89196	
	(ACCESSION NUMBER)	(THRU)
	4	None
	(PAGES)	(CODE)
	CR-62508	
	(NASA CR OR TMX OR AD NUMBER)	(CATEGORY)

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Summary:

Equipment was on hand at the start of the report period to measure intensity of turbulence, velocity profiles, friction factors, and rheological properties of polymer solutions. Additional equipment has now been procured to put the turbulence data on tape and to obtain autocorrelations and spectral analyses of the data. Probes are being developed to make cross velocity and other measurements.

Intensity of turbulence traverses have been made in a number of polymer solutions and solvents in a 2-inch tube. Most of the solutions were Newtonian and none were drag reducing under the conditions studied.

Equipment:

A hot wire anemometer and a correlator were purchased and a used two-channel studio tape recorder was purchased for recording turbulence signals from the anemometers. Calibration corrections for low frequency attenuation have been determined thus allowing signals from 10 cps to 15,000 cps to be analyzed.

The recorder was modified by the installation of a movable playback head whose position with respect to one of the recording heads could be accurately determined. Since the tape speed is known, variable time delays can be introduced into one channel by moving the playback head, and autocorrelations of the data can be made.

A spectral density analyzer was designed, constructed and calibrated as part of an M.S. thesis in Electrical Engineering. It is suitable for obtaining spectral analyses of turbulence signals over the range of 8 cps to 20,000 cps.

The pumping circuit including pumps, variable speed drives, manometers, flow meters and constant temperature reservoir had been built earlier and is located in an explosion-proof room. It contains test sections of $\frac{1}{2}$ -inch, 1-inch and 2-inch ID tubing. Its temperature control system holds the test fluid to $\pm 1^\circ\text{C}$ of the desired temperature. Using toluene, Reynolds numbers of 15,000 to 307,000 can be obtained. Lower Reynolds numbers in the turbulent range can be obtained in the capillary viscometer.

A traversing mechanism for pitot measurements in the 2-inch ID tube was adapted to hold either the hypodermic pitot tube or the hot-film probe.

Results:

Initial hot-film anemometry measurements were made in the 2-inch ID tube in benzene, cyclohexane and toluene and in a number of dilute polymer solutions of these solvents. Two concentrations of polyisobutylene in benzene, four concentrations of polyisobutylene in cyclohexane and two concentrations of high molecular weight polymethyl methacrylate in toluene and one of low molecular weight polymethyl methacrylate were measured. Reynolds numbers for the polymer solutions in the 2-inch tube ranged from 6,000 to 120,000. All polymer solutions except the last were drag reducing in small tubes, but none were drag reducing in the 2-inch tube. All but one of the solutions were Newtonian.

Intensity of turbulence traverses were made from the center to $\frac{r}{a} = 0.85$ on all runs. Spectral analyses have been made for one or more locations at two flow rates for most of the solutions. Auto-correlations were made on selected runs for checking the Fourier

transforms of the spectral analyses. Satisfactory checks were obtained.

The intensity of turbulence profiles and the frequency spectra obtained were generally similar to those obtained in other investigations in air. The frequency spectra are now undergoing careful analysis.

Future Plans:

Since the systems studied were not drag reducing in the 2-inch tube, the hot-film probe will be mounted in the 1-inch tube where drag reduction has been obtained. Higher molecular weight polymers will also be studied. Measurements have to be made quickly as polymer degradation is rapid for these high molecular weights.

Also under development are a probe designed to make measurements nearer to the wall, a smaller probe, and a probe to obtain cross velocity measurements.